Evidence of a Double Burden of Malnutrition among Rajbanshi Adolescent Boys

[1]PARTHA GHOSH†, [2]NITISH MONDAL‡, [1]JAYDIP SEN*

[1]Department of Anthropology, University of North Bengal, P.O.: N.B.U., Raja Rammohunpur, Dist.: Darjeeling 734013, West Bengal

[2]Department of Anthropology, Jadunath Sarkar School of Social Science, Assam University, Diphu Campus, Diphu, Dist: Karbi Anglong 782 462, Assam

E- mail: jaydipsen@rediffmail.com

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ABSTRACT: Malnutrition is one of the major public health problems affecting children and adolescents of the developing countries such as India and causes high mortality and long-lasting physiologic effects. Nowadays, individuals are being affected by a double burden of malnutrition. This dual burden refers to the prevalence of both undernutrition and overnutrition occurring simultaneously within a population. The present cross-sectional study has been carried out among 964 school-going adolescent boys aged 10 years - 18 years belonging to the indigenous Rajbanshi population and residing in the Siliguri sub-division of Darjeeling district, West Bengal, India. Height and weight were recorded and the body mass index (BMI) calculated. The prevalence of malnutrition was assessed utilizing stunting (<3rd percentile of the NCHS), thinness (BMI-for-age), while the prevalence of overweight-obesity was determined using the age-sex specific cut-offs of Cole *et al*. (2007). Mean values of weight, height and BMI gradually increased with age. The mean BMI ranged from 15.34 kg/m^2 to 20.21 kg/m^2 among the boys. The overall prevalence of stunting and thinness was observed to be 47.61% and 40.98% respectively. The overall prevalence of severe, moderate and mild thinness was observed to be 17.44%, 6.43% and 16.80% respectively. The prevalence of overweight (5.81%) and obesity (0.62%) were low. The existence of stunting and thinness indicated chronic nutritional deprivation and this was more pronounced than the burden of overnutrition among the adolescent boys. Appropriate intervention strategies are required to ameliorate their nutritional deficiency so as to achieve optimum growth.

INTRODUCTION

Several of the developed and developing countries have experienced rapid economic, demographic and nutritional transitions in recent decades resulting in changes in dietary habits, nutritional status, sedentary lifestyles and double disease burdens (Kolèić, 2012). Malnutrition is an important public health problem affecting more than 900 million individual world-wide. It is considered to be an area of concern in many of the developing countries in Asia (Nandy *et al*., 2005; Sen and Mondal, 2012a) and causes high child mortality and long-lasting physiologic effects. The double burden of malnutrition refers to the dual burden of undernutrition and overnutrition occurring simultaneously within a population. Recent trends

† Research Scholar
‡ Assistant Professor
* Associate Professor, Corresponding author

suggest that this double burden is becoming increasingly apparent in addition to the burden of diseases affecting individuals of the middle income countries such as China, Egypt, India, Mexico, Philippines and South Africa (Ke-You and Da-Wei, 2001; Galal, 2002; Stein *et al*., 2005; Subramanian *et al*., 2007; Iriart *et al*. 2011). It has been suggested that growth retardation is an indicator of overall social deprivation (WHO, '95; Medhi *et al*., 2007).

The period of adolescence in human development is characterized as a period of exceptionally rapid growth rate and maturation. Lower nutritional status has been observed to cause growth and developmental delays, increase susceptibility to infectious diseases, decrease cognitive functioning and increase risk of mortality among adolescents. Researchers have generally assessed the prevalence of undernutrition among adolescents using the conventional anthropometric indices of stunting (height-for-age), underweight (weight-for-age) and wasting (weight-for-height) following recommended international cut-offs (WHO, '95; Nandy *et al*., 2005; Mondal and Sen, 2010a). However, often these conventional anthropometric indices misjudge the actual magnitude of undernutrition due to overlaps. (Nandy *et al*., 2005; Sen *et al*., 2011a; Sen and Mondal, 2012). The body mass index (BMI) as measured by weight in kilogram (kg) divided by height in meter squared (m^2), is an inexpensive and non-invasive anthropometric measure that has been utilized to assess the nutritional status and thinness among adolescents (WHO, '95; Mondal and Sen, 2009). The BMI in relation to age (BMI-for-age) is also recommended as one of the best anthropometric indicator of thinness and overweight among them. The World Health Organization (WHO) recommended cut-offs are <5th and >85th percentile of the National Nutrition Examination and Health Survey Reference Population for thinness and overweight respectively (WHO, '95; de Onis *et al*., 2001). Recently, new international cut-offs have been proposed to assess overweight and obesity among children and adolescents in the age range of 2 years - 18 years by Cole *et al*. (2000). In yet another very recent development, Cole *et al*. (2007) have suggested new cut-offs for thinness for individuals within this age range.

Studies in India have primarily focused on the issue of undernutrition among different population groups (de Onis *et al*., 2001; Venkaiah *et al*., 2002; Nandy *et al*., 2005; Deshmukh *et al*., 2006; Medhi *et al*., 2006, 2007; Mondal and Sen, 2010a,b,c; Bisai *et al*., 2010; Das and Bose, 2011; Sen *et al*., 2011b; Sen and Mondal, 2012). Due to the immense population size, socio-economic disparities, illiteracy and inadequate access to health facilities, the prevalence of undernutrition remain appreciably high in India. Information on the nutritional situations among adolescents belonging to the developing countries such as India is needed to be generated for national as well as international comparisons. Assessments of their nutritional status also have the potential to play significant roles in formulating developmental strategies in this country. Recent studies have also reported a significant proportion of the urban and sub-urban populations being affected by overweight and obesity (Panjikkaran and Kumari, 2009; Deoke *et al*., 2012; Seth and Sharma, 2013). The objective of the present study is, thus, to evaluate the double nutritional burden (undernutrition and overweight-obesity) using standard anthropometric measures among adolescent boys belonging to an indigenous population of the country.

MATERIALS AND METHODS

Nature of the Subjects and Area of Study

The present cross-sectional study has been carried out among 964 school-going adolescent boys aged 10 years to18 years belonging to the indigenous Rajbanshi population. Ethnically, the Rajbanshi is the kin of the neighbouring Koch population of Assam. It is believed that they belong to a mixed population of Australoasian/Dravidian, with a hint of Mongoloid admixture. A recent study has opined that the Rajbanshi is a semi-Hinduized caste group located in between the clusters of Caucasoid caste populations and Mongoloid tribal populations (Kumar *et al*., 2004). Numerically they presently constitute the second largest schedule caste population in the state of West Bengal (18.40% and nearly 3.40 lakhs). The data for the present study were collected from five different government secondary schools in Kharibari and Atharokhai Block located in the Siliguri Subdivision in the district of Darjeeling, West Bengal, India. A multistage stratified random sampling method was used to identify the subjects. The data were collected during the period from July 2009 to December 2011. Special care was taken so that each category (age/sex) had a minimum of 100 subjects. All the subjects were free from any physical deformities and not suffering from any disease at the time of examination.

The study was conducted in accordance with the ethical guidelines for human experiments as laid down in the Helsinki Declaration of 2000 (Touitou *et al*., 2004). A verbal consent was also taken from each participant prior to the collection of the anthropometric and socio-economic data. Relevant data on the socio-economic and demographic variables (family size, parents' education, occupation, family income and dependent children in the family) were recorded using a pre-structured and pre-tested schedule based on a modified scale of Kuppuswamy as proposed by Mishra and Singh (2003). It was subsequently observed that all the boys belonged to a lower to a middle socio-economic group. To avoid selection bias, the subjects were examined for any nutritional deficiencies and related disorders by the local medical doctors. All approvals and consents were obtained from the school authorities prior to conducting the study.

Collection of Anthropometric Data

The school records were utilized to ascertain the age of the boys. The anthropometric measurement of height and weight were recorded using standard procedures (Weiner and Lourie, '81). Height was recorded to the nearest 0.10 cm with the help of an anthropometer rod with the head held in the Frankfort horizontal plane. The weight was taken using a portable weighing scale to the nearest 100 gm. The BMI was calculated by using the standard equation of WHO ('95). All the measurements were collected by two of the authors (NM and PG). The inter- and intra - observer differences were calculated for testing the coefficient of reliability (R) of the anthropometric measurements using the technical error measurement {TEM=" (ÓD^2/2N), D=difference between the measurements, N= number of individuals measured} following the method of Ulijaszek and Kerr ('99). Very high values of R (>0.98) were obtained for height and weight for both inter- and intra-observer TEM and these values were observed to be within the cut-off values of 0.95 as suggested by Ulijaszek and Kerr ('99). Hence, the anthropometric measurements recorded in the present study by NM and PG was considered to be reliable and reproducible and the TEM values were not incorporated for further statistical analyses.

Assessment of Nutritional Status

The prevalence of thinness has been assessed following the international age- and sex- specific BMI cut-off points proposed by Cole *et al*. (2007). The BMI values determine the definite grades of thinness as Grade-III (severe), Grade-II (moderate) and Grade-I (mild). These grades are similar to the classification of adult chronic energy deficiency (CED) as proposed by the WHO (WHO, '95). The boys were also identified as being overweight and obese based on the age and sex specific cut-offs proposed by Cole *et al*. (2000). Stunting (low height-for-age), reflecting linear growth retardation, was assessed by comparing height <3^{rd} percentile of the National Centre of Health Statistics (NCHS) reference value (WHO, '95).

Statistical Analysis

The descriptive statistical analysis of the data has been depicted in terms of mean and standard deviation (±SD). One way analysis of variance (ANOVA) using the Scheffe procedure was done to assess the differences in age and sex with respect to the anthropometric variables. Chi-square analysis was done to assess the differences in the prevalence of stunting and thinness with the data available among Indian adolescents. A p-value of <0.01 was considered to be statistically significant. The data were statistically analyzed using the Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL; version 15.0).

The least median square (LMS) model approach was used by taking into account the degree of skewness (L), central tendency (M: Median) and dispersion or the generalized coefficient of variation (S) for the calculation of reference percentile curves. This is a concept of age varying adjustment for skewness based on the Box-Cox transformation. The model converts the measurements for a subject of known age and sex to evaluate the percentile and standard deviation score or z-score (Cole and Green

'92; Cole *et al.*, '98). The LMS model approach software computer program that fitted smooth percentile curves to reference data using the LMS model (Cole and Green, '92) was utilized to obtain age-specific BMI percentile curves of the 3rd, 10th, 25th, 50th, 75th, 90th and 97th percentiles.

RESULTS

The age-specific distribution of the means (±S.D.) of height, weight, BMI and prevalence of stunting (<3rd percentile of the NCHS) and different grades of thinness among Rajbanshi boys are depicted in Table 1. Mean values of weight, height and BMI gradually increased with age but an exception was noticed in the 17 years - 18 years age group for height and in the 16 years category for BMI. The mean BMI ranged from 15.34 kg/m^2 to 20.21 kg/m^2 among the boys. Using ANOVA, the overall difference in age-specific mean values of weight (F value=138.10; d.f.: 9, 955), height (F value=165.19; d.f.: 9, 955) and BMI (F value=21.49; d.f.: 9, 955) were observed to be statistically significant (p<0.01). The age-specific BMI percentile curves of the 3rd, 10th, 25th, 50th, 75th, 90th and 97th using the LMS model approach are shown in Figure 1.

The overall prevalence of stunting and thinness was observed to be 47.61% and 40.98% respectively (**Table 1**). The prevalence of stunting was higher among the boys in the higher age groups (14 years - 18 years) and reached the highest in 18 years (74.78%). The age-specific prevalence of stunting ranged from 30.56% (13 years) to 74.78% (18 years). The overall prevalence of severe (Grade-I), moderate (Grade-II) and mild (Grade-III) thinness were observed to be 17.44%, 6.43% and 16.80% respectively. The age-specific highest prevalence of the grades of thinness (severe, moderate and mild) was observed among the boys aged 16 years (26.42%), 12 years (11.43%) and 11 years (25.00%) respectively, while the lowest prevalence was observed in the ages of 18 years (severe: 9.57%; moderate: 3.48%) and 14 years (10.48%) respectively. The overall prevalence of the thinness grades ranged from 26.42% to 3.48%. The age-specific combined different grades of thinness were observed to be higher among those aged 16 years (51.89%) and lower among those aged 18 years (28.70%). The age-specific overall prevalence of overweight (5.81%) and obesity (0.62%) was low. The age-specific trend in prevalence of overweight was apparently absent but a higher and lower prevalence was observed in the ages of 12 years (11.21%) and 16 years (3.77%) respectively. The age-specific prevalence of stunting, overall thinness and overweight among the Rajbanshi boys is shown in **Figure 2.**

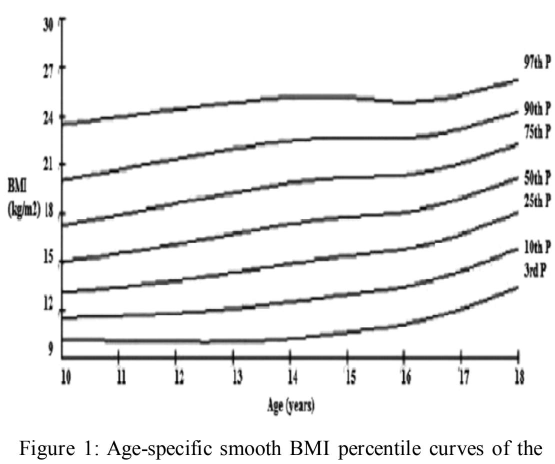

Figure 1: Age-specific smooth BMI percentile curves of the Rajbanshi boys using the LMS method

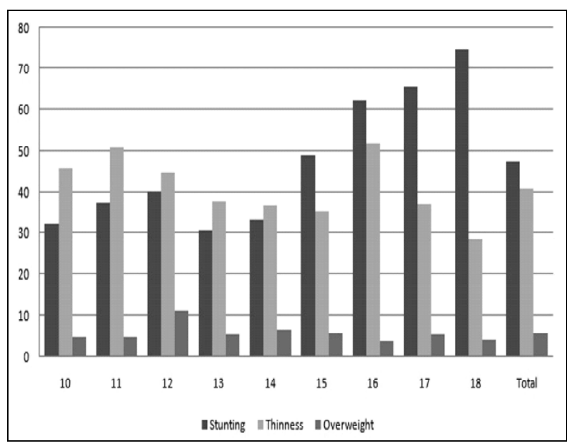

Figure 2: Bar diagram showing the prevalence of malnutrition among the Rajbanshi boys

DISCUSSION

Trends in nutritional status in various countries indicate a slight decrease in malnutrition with an associated acceleration in the prevalence of overweight and obesity. The prevalence of

TABLE 1

Age-specific subject distribution, mean (± SD) of height, weight and BMI and prevalence of stunting, thinness, overweight and obesity among the Rajbanshi boys

Age (Years)	No. of Subjects	Height (cm)	Weight (kg)	BMI (kg/m^2)	Stunting (<3rd percentile)	Thinness† (low BMI for age) Severe	Moderate	Mild	Overall	Overweight††	Obesity††
10	105	131.10 ±8.35	26.13±4.31	15.34±3.04	34 (32.38)	17(16.19)	12(11.43)	19(18.10)	48 (45.71)	05(4.76)	01(0.95)
11	104	136.58 ±9.95	29.17±6.33	15.72±3.43	39 (37.50)	20(19.23)	07(6.73)	26(25.00)	53 (50.96)	05(4.81)	03(2.88)
12	107	140.07 ±10.14	31.83 ±6.76	16.45±4.12	43 (40.19)	24(22.43)	07(6.54)	17(15.89)	48 (44.86)	12(11.21)	01(0.93)
13	108	147.26 ±9.75	36.41 ±8.23	16.81±3.53	33 (30.56)	17(15.74)	07(6.48)	17(15.74)	41 (37.96)	06(5.56)	00(0.00)
14	105	151.42 ±9.17	39.30 ±8.39	17.23±4.17	35 (33.33)	23(21.90)	05(4.76)	11(10.48)	39 (37.14)	07(6.67)	01(0.95)
15	104	154.15 ±8.41	43.59 ±7.59	18.44±3.52	51(49.04)	15(14.42)	06(5.77)	16(15.09)	37 (35.58)	06(5.77)	00(0.00)
16	106	159.22 ±7.40	44.27 ±8.35	17.48±3.32	66 (62.26)	28(26.42)	10(9.43)	17(16.04)	55 (51.89)	04(3.77)	00(0.00)
17	110	158.99 ±5.38	47.50 ±7.25	18.87±3.25	72 (65.45)	16(14.55)	04(3.64)	21(19.09)	41 (37.27)	06(5.45)	00(0.00)

TABLE 2

Comparison of the prevalence of stunting and thinness reported for adolescent boys from India

Area / Region	Age group	N	Reference	Stunting (%)	Chi-value	Thinness (%)	Chi-value	Reference
Hooghly district, West Bengal	10-17 years	82	WHO/NCHS	52.44	0.24	36.58	0.26	Das *et al*., 2007
Dibrugarh, Assam	10-18 years	291	WHO/NCHS	47.40	0.001	59.50	10.89**	Medhi *et al*., 2007
Darjeeling, West Bengal	10-17 years	376	WHO/NCHS	43.10	0.83	53.10	5.83*	Mondal and Sen, 2010b
South India	10-16 years	589	WHO/NCHS	38.80	4.62*	64.6	26.24**	Haboubi and Shaikh, 2009
Paschim Medinipur, West Bengal	11-18 years	665	WHO/NCHS	28.40	26.87**	24.20	24.82**	Bisai *et al*., 2011
Indian adolescents	10-17 years	6088	WHO/NCHS	42.20	3.87*	66.90	61.30**	Rao *et al*., 2006
Kolkata, West Bengal	9-16 years	856	WHO/NCHS	11.20	156.58**	50.50	6.16*	de Onis *et al*., 2001
Assam, Northeast India	9-14 years	204	WHO/NCHS	51.80	0.34	51.80	2.90	Medhi *et al*., 2006
West Tripura, Northeast India	8-15 years	623	WHO/NCHS	27.90	27.23**	38.37	0.46	Sarkar *et al*., 2012
Agartala, Tripura, Northeast India	8- 15 years	365	WHO/NCHS	7.67	99.10**	17.81	33.28**	Sil *et al*., 2012
Rajbanshi, Darjeeling West Bengal	10-17 years	964	WHO/NCHS, Cole *et al*.	47.61	-	40.98	-	Present study

*p<0.05, **p<0.01

malnutrition among adolescents is considered to be a major public health problem in the developing countries such as India where the vast majority of the populations are undernourished and underprivileged (Mondal and Sen, 2010a). Assessments of nutritional status are therefore, important for the improvement of the health and nutritional status and overall development of the population concerned. Here the role of the anthropometric measurements and indices bear prime importance (de Onis *et al*., 2001; WHO, '95; Nandy *et al*., 2005; Medhi *et al*., 2007; Mondal and Sen, 2009, 2010a, Sen and Mondal, 2012).

A comparative presentation of the prevalence of stunting and thinness and statistical differences using chi-square analysis among adolescents from different Indian populations along with that of the present study (Rajbanshi) is depicted in **Table 2**. The results of the present study showed a higher prevalence of stunting than that reported in the earlier study of Mondal and Sen (2010b) in West Bengal (43.10%, $p>0.05$), but lower than those reported by Das *et al*. (2007) also from West Bengal (52.45%, $p>0.05$) and Deshmukh *et al*. (2006) from rural Wardha (50.70%, $p>0.05$). In a study from Assam, Medhi *et al*., (2007) reported that 47.40% ($p>0.05$) of boys were affected by stunting. Utilizing data from the National Nutrition Monitoring Bureau, Venkaiah *et al*. (2002) reported about 39.00% of the adolescents from the rural areas to be stunted. The primary reason behind stunting indicates long term cumulative inadequacies of health and nutrition and an insufficient intake of nutrients during the early stage of childhood (WHO, '95; Medhi *et al*., 2007). One of the key causes of this undernutrition could be the lack of access to sufficient food and basic resources and socio-economic disparity across the populations.

In the present study, an assessment of thinness (low BMI-for-age) among the adolescent boys was undertaken using the newly proposed cut-off points of Cole *et al*. (2007). These new cut-off points were suggested to encourage direct comparison of trends in the worldwide prevalence of thinness among children and adolescent. Prior to these cut-offs, there were no suitable thinness cut-off points for this age group (2 years - 18 years). These cut-off points were derived from the multi-centre data obtained from the developed countries of the United States, Great Britain, and the Netherlands and a developing country Brazil. Moreover, it has been proposed that undernutrition is better assessed as thinness (low BMI-for-age) rather than wasting (low weight-for-height) (Cole *et al*., 2007). As some studies from India had already reported the magnitude of thinness among children and adolescents in India using these newly proposed cut-off points (Chakraborty and Bose, 2009; Mondal and Sen, 2010c; Bisai *et al*., 2010; Das and Bose, 2011; Das *et al*., 2012), use of these BMI cut-off points can be taken to be valid among Indian children and adolescents.

It was observed by various researchers (de Onis *et al*., 2001; Medhi *et al*., 2006, 2007; Rao *et al*., 2006; Haboubi and Shaikh, 2009; Mondal and Sen, 2010b; Shivaramakrishna *et al*., 2011) that using the recommended cut-off points and references of the WHO ('95), there was a significantly ($p>0.05$) high prevalence of thinness among Indians, with more than 50.00% of the adolescents being affected in the higher age groups (Table 2). It is apparent from this study that there is an occurrence of a high prevalence of thinness (40.98%) among the Rajbanshi adolescent boys (Table 1). Using the cut-off points of Cole *et al*. (2007), higher prevalence of overall thinness was reported among Bengalee boys by Chakraborty and Bose (2009), rural adolescents from Darjeeling district by Mondal and Sen (2010c), Kora-Mudi boys by Bisai *et al*. (2010), Santal boys by Das and Bose (2011), Nepali boys by Das and Banik (2011) and rural boys of Kharagpur, West Bengal by Das *et al*. (2012). However, the prevalence of thinness in the present study was higher than those reported in the studies of Das *et al*. (2007), Bisai *et al*. (2011), Sarkar *et al*. (2012) and Sil *et al*. (2012).

Evidently, the problem of thinness (low BMI-for-age) is persistent among adolescent boys from different Indian populations. Those adolescents suffering from thinness are more likely to develop into thin adult individuals with a low BMI or low chronic energy deficient status that can have a negative impact on their work productivity as well as lead to greater prevalence of morbidity and mortality (WHO, '95). Studies have also reported that that prevalence of thinness might actually be more frequent than obesity among Indian adolescents (de Onis *et al*., 2001; Deshmukh *et al*., 2006; Medhi *et al*., 2006, 2007; Rao *et al.*, 2006; Mondal and Sen, 2010b; Shivaramakrishna *et al.*, 2011). The present study has observed that the magnitude of overweight (5.81%) and obesity (0.62%) was lower than thinness. Low prevalence of overweight was also reported among rural adolescents from Assam (0.30%) (Medhi *et al.*, 2007), rural Wardha (2.00%) (Deshmukh *et al.*, 2006) and Darjeeling (0.30%) (Mondal and Sen, 2010b). A marginally higher prevalence of overweight (5.00%) has been reported in Bengali adolescents (de Onis *et al.*, 2001). Recent studies have also confirmed that the prevalence of early childhood obesity is increasing among Indian children and adolescents (Deoke *et al.*, 2012; Seth and Sharma, 2013). These trends may accelerate such prevalence in the decades among the most populous middle-income country like India.

CONCLUSION

The existence of the prevalence of stunting and thinness is much higher among the Rajbanshi adolescent boys and this is indicative of chronic nutritional deprivation. There is also a marginal prevalence of overweight and obesity. The results show that the problem of undernutrition is more pronounced than the burden of overnutrition among them. These Rajbanshi adolescent boys are experiencing a nutritional dual burden of malnutrition and need appropriate intervention strategies to ameliorate the nutritional issues so as to achieve their optimum growth potential. The results also highlight the need to focus on nutrition-related diseases and to understand the specific causes to impose the double burden of malnutrition in the population. Further studies should be conducted using of newly proposed cut-offs of thinness for the assessment of nutritional status of different Indian populations, especially the nutritionally vulnerable segments.

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